STRATEGY RESEARCH PROJECT

BRITISH TECHNOLOGY AND INNOVATION IN THE BATTLE OF BRITAIN: BLUEPRINT FOR THE FUTURE?

BY

LIEUTENANT COLONEL THOMAS W. YOUNG
United States Army

USAWC CLASS OF 2001

U.S. ARMY WAR COLLEGE, CARLISLE BARRACKS, PA 17013-5050

USAWC STRATEGY RESEARCH PROJECT

British Technology and Innovation in the Battle of Britain: Blueprint for the Future?

by

Lieutenant Colonel Thomas W. Young
United States Army

Colonel Paul F. Guzowski
Project Advisor

U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

AUTHOR: Thomas W. Young, LTC, USA

TITLE: British Technology and Innovation in the Battle of Britain: Blueprint for the Future?

FORMAT: Strategy Research Project

DATE: 10 April 2001 PAGES: 38 CLASSIFICATION: Unclassified

Following the horrors of trench warfare in World War I, military strategists proclaimed that the bomber was the weapon of the future. They wrote extensively that bombing would be far more effective than any other form of warfare. Some proposed that the only defense against attack by bombers was offensive bombers. Others thought that innovation and technology could develop a defense against this revolutionary new form of warfare.

Perhaps there are parallels between the situation facing the British in the years leading up to the Battle of Britain and the situation facing the U.S. today. This paper reviews the Battle of Britain, describing the German plan of attack and the British plan of defense. The article analyzes some of the technology advances and innovations that enabled the British to defeat Germany in this revolutionary new form of warfare. It discusses some of the innovations and technological solutions being developed to transform the United States' Cold War military forces into a 21st Century force capable of defending against emerging threats. Finally, it proposes that Britain's keen analysis of the threat and their application of technology to defeat that threat could reveal a blueprint for the United States' preparation for future conflict.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

BRITISH TECHNOLOGY AND INNOVATION IN THE BATTLE OF BRITAIN: BLUEPRINT FOR THE FUTURE?

Following the horrors of trench warfare in World War I, military strategists proposed that the bomber was the weapon of the future. The Italian General Giulio Douhet wrote extensively that bombing would be far more effective than any other form of warfare. U.S. Brigadier General Billy Mitchell talked of rapid, decisive air battles. During these years, Britain's foremost military thinkers of the time, Liddell Hart and JFC Fuller clearly saw the bomber as the wave of the future. British Prime Minister Stanley Baldwin said, ". . . the bomber will always get through. The only defence is offence, which means that you have to kill more women and children more quickly than the enemy if you want to save yourselves."[1] Others thought that innovation and technology could develop a defense against this revolutionary new form of warfare. These were some of the issues facing British military leaders in the years leading up to World War II.

Likewise, many military strategists now claim that with the end of the Cold War, the days of two opposing nations slugging it out in a conventional war with tanks, fighters, and aircraft carriers are gone forever. They see new forms of asymmetric warfare on the horizon. These thinkers claim that while the United States must maintain a credible conventional force for the interim to deal with the inevitable small scale contingencies, the focus should be on developing Information Operations (IO) capabilities, militarizing space, building ballistic missile defenses, and developing precision weapons delivered by unmanned systems.

Perhaps there are parallels between the situation facing the British in the years leading up to the Battle of Britain and the situation facing the U.S. today. This paper reviews the Battle of Britain, describing the German plan of attack as well as the British plan of defense. The article analyzes some of the technology advances and innovations that enabled the British to defeat Germany in this revolutionary new form of warfare. It discusses some of the innovations and technological solutions being developed to transform the United States' Cold War military forces into a 21st Century force capable of defending against new and emerging threats. Finally, it proposes that Britain's keen analysis of the threat and their application of technology to defeat that threat could reveal a blueprint for the United States' preparation for future conflict.

BATTLE OF BRITAIN OVERVIEW

"Never in the field of human conflict was so much owed by so many to so few."[2] British Prime Minister Winston Churchill paid tribute to the British airmen of the Royal Air Force (RAF) Fighter Command with these words in a speech to the House of Commons. These brave

airmen are generally credited with saving Britain from a German invasion in the summer and fall of 1940, and they no doubt played a pivotal role in the defense of Britain. The importance of their skillful and determined performance in the famed Battle of Britain is universally recognized.

However, another group of people was also instrumental to the defense Britain. The inventors and developers of some remarkable new technological advances were equally decisive in protecting Britain from German invasion. RAdio Direction-finding And Ranging (RADAR), Identify Friend or Foe (IFF), and a remarkable Fighter Control System were essential elements of the defense, as were developers of the Spitfire and Hurricane aircraft.

The gravity of the coming air battle was clear to all concerned, on both sides of the English Channel. If the British were successful in repelling Germany's air attack, it would be almost impossible for the Germans to launch an invasion attempt. On the other hand, if the Luftwaffe defeated Britains fighters and gained air superiority, it would be equally impossible for Britain to successfully defend against attack. Of the pending attack, the British Chiefs of Staff declared:

> Our efforts must therefore be concentrated on taking all steps necessary to meet the imminent threat of attack with which we are confronted. . . . The issue of the war will almost certainly turn upon our ability to hold out during the next three months.[3]

If the Luftwaffe successfully defeated RAF's Fighter Command, German bombers could then destroy Britain's ground defenses, leaving Britain at the mercy of the Wehrmacht. Clearly, the Battle of Britain would be among the most decisive encounters of World War II.

Nazi invasion of the Low Countries and France began on May 10, 1940, and by May 21 the Nazi army had reached the English Channel. During the last days of May and the first days of June some 330,000 British and Allied forces were withdrawn from France at Dunkirk. By the time of the French surrender on 22 June, the RAF had lost more than 1,000 aircraft, some 500 of them fighters. Homeland defense was reduced to 331 Spitfires and Hurricanes supported by 150 second-line fighters. Furthermore, 435 British pilots had been lost.[4]

Air Chief Marshal Sir Hugh Dowding, Commander-in-Chief of the RAF's Fighter Command estimated that he would need a minimum of fifty-two squadrons of fighters to defend Britain from invasion. By the end of the Dunkirk evacuation, Fighter Command's effective fighting strength had been reduced to twenty-six squadrons, half of the force he thought would be required to protect Britain.

Hitler had hoped to avoid the necessity for an invasion of England and put out several peace feelers to London, which were clearly rejected by Winston Churchill. Following the

rejection of Hitler's 'appeal to reason' in July 1940, the German high command felt there was no other recourse than to let the guns speak.[5] In July of 1940. Hitler issued Directive No. 16, which stated:

> Since England, in spite of her hopeless military situation, shows no signs of being ready to come to a compromise, I have decided to prepare a landing operation against England, and, if necessary, to carry it out.[6]

Thus, Operation SEA LION, as Germany named its plan for the invasion of England, was set into motion. Expecting some three months of good weather prior to the arrival of the autumn storm season that would make the invasion impossible, the Luftwaffe began preparing to execute the plan. The tried and true formula of destroying of the enemy air force, followed by the rapid advance of ground forces supported by aggressive air attacks had worked well from the Poland campaign onward; this was the planned method to be employed in the invasion of England. The only difference in the German estimate was that since the RAF was the largest air force yet encountered, its destruction would take longer that the usual 12 to 48 hours allotted to previous air forces.[7]

THE GERMAN PLAN OF INVASION

Once the Luftwaffe had gained air superiority, two Army Groups planned landings on the southeastern beaches of England. Army Group A under General Field Marshall Karl Von Rundstedt would cross the channel to land near Dover. General Ernst Busch would lead the Sixteenth Army to the right of Army Group A, landing near Ramsgate. General Strauss's Ninth Army would land to the left of Army Group A near Hastings. Army Group B would cross from Cherbourg to land between Weymouth and Sidmouth in the Devon and Dorset area of England. The main force of Army Group B would land near Lyme Bay and then would push north to Bristol and Birmingham. The landings would be broken up into waves and the initial wave would comprise ten divisions supported by some 30,000 paratroopers on each side who would cut communications, secure bridges and railways, and secure the flanks.[8]

The Luftwaffe's initial plan began to take shape. The Germans occupied airfields in the conquered countries of France, Belgium, Holland, and Norway and began to stock them with aircraft, fuel, bombs, and ammunition, converting them into operational German airfields. As depicted in Figure 1, Goering divided the territory into five operational Sectors to be known as Luftflotten or Air Fleets. Luftflotte 1 and 4 were based in Germany and Poland, Luftflotte 2 was based in northeastern France, Luftflotte 3 in central and northern France, and Luftflotte 5 was based in Norway.

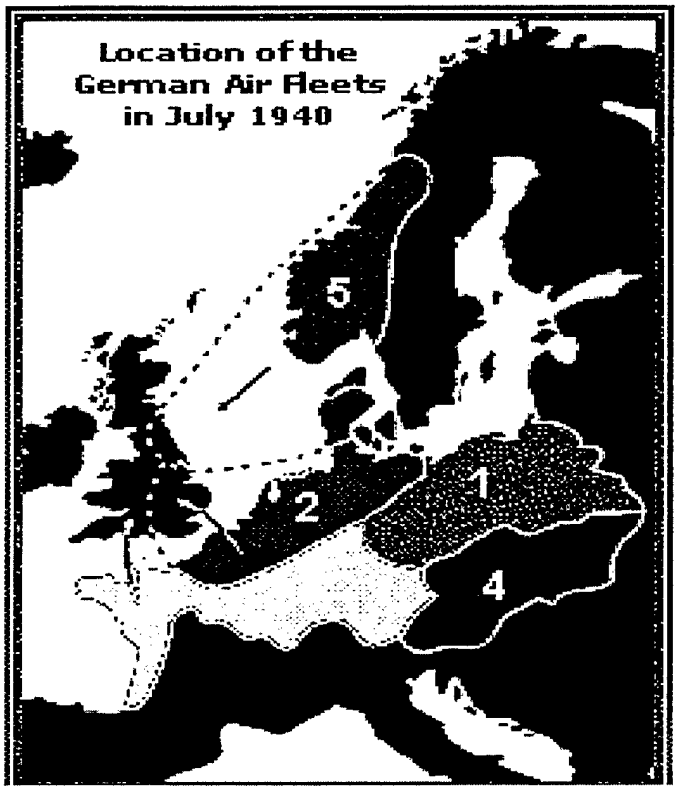

FIGURE 1, LUFTWAFFE OPERATIONAL SECTORS[9]

Each Luftflotte was organized into a self-contained unit, equipped with a full range of aircraft with a complete command, control, and support structure. Each was allotted a specific area of operation. In preparation for the Battle of Britain, a boundary line was drawn down the middle of England; Luftflotte 2 and 3 were allocated operational areas to the east and west of that line, while 5 was allocated the Northeastern part of England.

Generalfeldmarschall Albert Kesselring, headquartered in Brussels, was placed in command of Luftflotte 2. Generalfeldmarschall Hugo Sperle, who enjoyed great success in the Kondor Legion in the Spanish Civil War, was appointed to command of Luftflotte 3, headquartered in Paris. Generaloberst Hans-Juergen Stumph was placed in command of Luftflotte 5, covering Norway and Denmark.[10]

The German Air Force was given two primary tasks: (1) Eliminate the RAF and its airfields and (2) Strangle Great Britain by attacking it's shipping and ports. The RAF would be eliminated in two stages. In the first stage, the Luftwaffe would destroy the RAF by eliminating fighter airfields and their aircraft starting in the South, then extending northward until all RAF (bomber and fighter) bases were eliminated. As part of that same plan, the bombing attacks would be directed against the British aircraft industry, in an effort to eliminate British aircraft production capability.

The Germans thought the first phase, the elimination of the RAF Fighter Command in the South would take only four days, and that the whole RAF could be eliminated in four weeks. Once total German air supremacy was established over the English Channel and southern England, a Blitzkrieg invasion would be launched at the coast between the Isle of Wright and Dover.[11] The Luftwaffe would play a supporting role by mopping up any residual opposition by the RAF

THE BRITISH PLAN OF DEFENSE

Air Chief Marshal Sir Hugh Dowding located his headquarters in an underground bunker at Bentley Priory, just west of London. He divided his forces into four numbered groups, each commanded by an Air Vice-Marshal: Sir Christopher Quinton Brand for Group 10 in the southwest; Keith Park for Group 11 in the southeast; Sir Trafford Leigh-Mallory for Group 12 covering the middle of England; and Richard Saul for Group 13, covering the north and Scotland. Each group was subdivided into several sectors and all elements of the defense were integrated into what came to be called the RAF Fighter Control System.

THE BATTLE BEGINS

The Battle of Britain formally began on July 10, 1940 when more than 100 German bombers with fighter escorts attacked targets in Yorkshire and Kent. Although there are no official phases, British historians have divided the Battle of Britain into four general phases because of periods of different tactics and scenarios. Phase 1 (10 July – 7 August) consisted primarily of attacks on ports and channel convoys. Phase 2 (8 August – 6 September) was aimed primarily at RAF airfields. Phase 3 (7 September – 30 September) consisted of the bombing of London, major cities, and airfields. Phase 4 (1 October – 31 October) was a period of concentrated night bombings. Germans generally concur with those time frames, but from the Luftwaffe view, there were two additional phases. A fifth phase, called the "End of the Air Battle" occurred from 1 November to 8 February. The sixth and final phase started on 9 February and ended with the heavy bombing raid on London on the night of 10 and 11 May.[12]

Phase 1

Following the fall of France and the evacuation of the British and Allied forces at Dunkirk, German air attacks had focused on attacking British shipping convoys in the English Channel with a few scattered small-scale raids on ports and the aircraft industry. Although Goering did not have authority yet from Hitler to initiate the invasion of Britain, he hoped to tempt the British fighters to leave their bases and come out into the Channel and fight. This would give the

Luftwaffe a fairly accurate idea how quickly the RAF could react to an attack and how many fighters they would send up with each attack. In other words, Germany was testing the efficiency and strength of the RAF.

The Germans initiated their attack just as Dowding had predicted in a speech to a group of RAF students way back in 1936. He said that if Germany invaded England, they would first attack all forms of merchant shipping bringing in supplies into the country, knowing that Britain relied heavily on overseas products. Since RAF fighters would be forced to defend the shipping lanes, they would be vulnerable to attack by Luftwaffe fighters.[13] His prophecy appeared accurate.

Throughout July and into August, the Luftwaffe maintained its attack against Channel convoys and ports. Some of the attacks were rather small scale while others could be termed as full-scale battles. Sporadically, England's southeast coast, ports, and harbors were attacked, as were nearby airfields. Suspecting the importance of the British radar towers, they also attacked the towers and stations on the South coast, badly damaging some of them.

Phase 2

After coming to the realization that he would not reach a political solution with Britain, Hitler issued Directive Number 17 on 1 August 1940, calling for the "final conquest of England."[14] The Luftwaffe was instructed to destroy the British fighter forces with attacks on "flying formations, their ground organizations, and their supply organizations; secondly, against the aircraft production industry . . ."[15]

Goering named the air operation Adlerangriff (Eagle Attack) and set it to begin on Adlertag (Eagle Day), first set for 10 August, then delayed until 13 August due to bad weather. The Luftwaffe had assembled an impressive air fleet for the invasion of England. On 10 August, Luftflotten 2 and 3 reported the following aircraft ready for combat: 875 bombers, 316 dive-bombers, 702 single-engine fighters, 227 twin-engine fighters, and 45 long-range reconnaissance aircraft. At Luftflotte 5 in Norway, there were 123 bombers, 34 twin-engine fighters, and 23 long-range reconnaissance aircraft. A total of 2350 combat-ready frontline aircraft faced Britain.[16]

Across the Channel, the RAF's Fighter Command had 704 operational fighters with 289 in reserve. Some 1,250 pilots were assigned to the sixty squadrons occupying 39 bases.[17] By early August, Dowding had a fair picture of how he would have to conduct the air battle. On the strategic level, Fighter Command had to hold out only until autumn brought bad weather. The arrival of autumn and winter storms would preclude any German invasion. On the operational

level, the RAF would have to meet enemy bomber formations with sufficient strength to impose a heavy rate of attrition on the attackers and to tie the fighter escorts closely to the defense of vulnerable bomber formations. Meanwhile, due to the limited range of the Bf109s, RAF crews could train, rest, and refit in the west of England beyond the range of the most fighter attacks. They would be in position to attack any German bomber formations that ventured beyond the range of their fighter escorts.

Believing that the British radar system had been sufficiently damaged, the Luftwaffe began massive air raids on the airfields, focusing on 11th Group located in the Southeast of England. This phase, in which the Luftwaffe planned to destroy Fighter Command, was the most critical because it was during this period that Fighter Command came closest to destruction.

Losses on both sides were devastating. During the four days of heavy assaults from August 13 – August 18, Germany lost 236 fighters and bombers, yet the RAF fighter force seemed as strong as ever. In reality, the RAF also suffered tremendously, losing 213 Spitfires and Hurricanes between August 8 and August 18.[18] Although losses were exceeding factory production capacity, the greater concern was the loss of pilots. Since 1 July, Fighter Command had lost eleven of forty-six squadron commanders and thirty-nine of ninety-seven flight commanders were killed or wounded.[19] Replacement pilots were reaching their squadrons fresh out of flight training with only twenty hours in Spitfires or Hurricanes. Ground crews working in the open suffered many casualties from the attacks, and many maintenance facilities were destroyed in the bombing raids. During this phase, the Germans began night raids to keep the British from repairing damage overnight. During one of these night raids of August 24, 170 German bombers mistakenly bombed London. The next day, in retaliation, the RAF's Bomber Command sent eighty-one Hampden bombers to bomb factories in Berlin.

Phase 3

Just when it seemed that Fighter Command would be decimated, the Germans changed their tactics. Hitler was enraged by the attack on Berlin. Since it seemed that the attacks on the RAF airfields were not destroying enough RAF fighters, he ordered a change in the bombing strategy. By bombing cities and factories, Hitler hoped to destroy the factories that built the fighter aircraft and to break the British people's will to fight. Furthermore, he hoped that the RAF fighters would mass to try to protect the cities, which would make it easier for the Luftwaffe to shoot them down sufficient aircraft to give them air superiority. On 7 September, five hundred

bombers accompanied by six hundred fighters bombed London.[20] That night, two hundred fifty bombers returned. Hundred of civilians were killed and wounded.

This change in tactics was actually a fatal mistake for the Germans. The change in targets now gave 11th Group a chance to repair its airfields, radar, and control system stations. Because the German Bf 109 could only carry enough fuel for about twenty minutes of flight over Britain, London was on the edge of its range. Thus, the bombers were frequently without their protective escorts. Additionally, the German raids were now within range of 12th Group. Knowing the target of any German raid would be London and the industrial centers, the British controllers now had time to launch a large number of fighters to attack the German formations before they had time to bomb their targets. Just when Fighter Command was in danger of being defeated, the Germans actually helped Fighter Command recuperate by changing targets and strategy.

Phase 4

As the air campaign continued into October, daylight bombing losses had become too heavy and the German bombers had started to operate only at night, causing devastating damage to Britain's cities. The night raids continued throughout the month of October, but the Germans were suffering unsustainable loss rates, losing more aircraft than their factories could produce. By October 31, the Germans realized that their efforts to invade Britain had failed. Hitler abandoned Operation SEA LION and turned his attention to Russia. Ironically, for such a groundbreaking battle, "the first to be decided purely in the air and the first real test of air power as a defensive and offensive weapon,"[21] the Battle of Britain gradually petered out more than actually ending.

TECHNOLOGY / INNOVATIONS

Clearly the fighters and their determined crews played the more visible and perhaps more heroic role in defending Britain from the German air campaign. However, without the inventors, developers, and visionary innovators who developed new technology and found innovative ways to harness existing technology, the Germans would surely have gained air superiority, clearing the way for Operation SEA LION. With no air cover, could Britain have fared any better than Poland or France against an all-out German offensive? Some of these new technologies and innovations that played such a decisive role are worth examining more closely.

RADAR

Fighter Command knew an invasion loomed but did not have enough fuel or fighters to maintain standing patrols in anticipation of enemy raids. Nor did the country have the time to train another crop of brave and intelligent young pilots if German bombers surprised them on the ground. Britain's best hope for survival rested on being able to spot the Luftwaffe far out over the English Channel and then deploying its thin resources to meet the threat at hand. Thus, the nation depended on the Chain Home radar network.

In the days leading up to the outbreak of World War II, the British Air Ministry received numerous proposals for new weapons. One of these was a 'death ray' that could destroy an aircraft in flight. The proposal was sent to Robert Watson Watt, the Superintendent of the Radio Research Station for evaluation.

He asked Arnold Wilkins, a member of his staff, to calculate just how much radio energy would be required to damage an aircraft in flight or to adversely affect its crew. Wilkins realized that no damage could possibly be done to the aircraft by directing radio waves at it. However, there was a real possibility of being able to detect the aircraft by the waves that were reflected back. Watts' reply to the Air Ministry on February 12, 1935 was destined to have a decisive effect on the course of the war.

The Air Ministry had already determined that a key fundamental of air defense was to obtain early warning of approaching aircraft. The theory that radio waves reflected from the metal skin of an aircraft was not completely new, but it was technically difficult to achieve. Because the energy returned from an aircraft in this way would be only a very small fraction of the energy sent out, practical application would be difficult to achieve and not particularly useful. But in 1935, to a country increasingly aware of the threat of war, the concept was worth exploration.

On 17 June, the experimental system detected its first clear echo at seventeen miles. It turned out to be a Scapa flying boat from Felixstowe Air Station, which the team was able to track for about half an hour as it flew up and down the coast.[22] Significant improvements were rapidly achieved. By the beginning of 1936, the radar team could detect aircraft at over 100 miles. They developed a method of direction finding and incorporated a height finding facility. In 1938, the defenders put into operation a chain of five stations in what was to become known as the Chain Home (CH) system. By 1940, the entire East and South coasts were covered against aircraft flying at up to 15,000 feet at a range of 120 miles. The transmitting antennas were mounted on metal towers 360 feet high and the receiving antennas were mounted on 240-foot wooden towers.[23]

However, the CH stations could not detect aircraft operating below 5,000 feet. For this purpose, the RAF installed a more complicated Chain Home Low (CHL) system. It had a range of only about 50 miles and could read only straight ahead. To supplement the CHL stations, they developed mobile units to be mounted on vehicles. Both versions of CHL had rotating antennas and were much more precise at direction finding that the main CH sets. While the CH system relied on a wide 'floodlight' type beam, the CHL used a much narrower rotating beam that operated more like a 'lighthouse' type beam.[24]

HIGH FREQUENCY DIRECTION FINDING

Radar stations and the Observer Corps worked very well detecting and tracking hostile aircraft attacking from across the English Channel, but for the defense system to function, it was necessary for the Sector Controllers to accurately know the position of the RAF fighters. Without knowing the location of their own aircraft, it would have been impossible to vector them to intercept an inbound attack.

This was done by a High Frequency Direction Finding (HF/DF) system which was used much like today's modern Identify Friend or Foe (IFF) equipment. All British fighters were equipped with a TR9D transmitter receiver. Commonly called a "pip squeak" for the cartoon character of the day, the unit had two channels. One channel was used for voice communications with his Sector Control while the other channel was set on a frequency common to all squadrons. That second channel, the "pip squeak," automatically transmitted a radio signal for fifteen seconds of every minute. The Sector Control stations on the ground detected this signal, and by triangulation from two or more stations, the position could be accurately determined. With an accurate picture of both friendly and enemy aircraft locations, Sector Controllers could accurately track and direct the battle.

THE RAF FIGHTER CONTROL SYSTEM

All of the individual components of the innovative British defense system were integrated into what became known as the RAF Fighter Control System. All of the Chain Home and Chain Home Low Stations, observer posts, the Observer Corps Center, balloon barrage stations, fighter airfields, direction finding stations, direction finding triangulation stations, anti-aircraft guns, Sector Control Stations, Group Headquarters, and the Fighter Command Headquarters Filter and Operations Room were linked in this ingenious defense as shown in Figure 2.

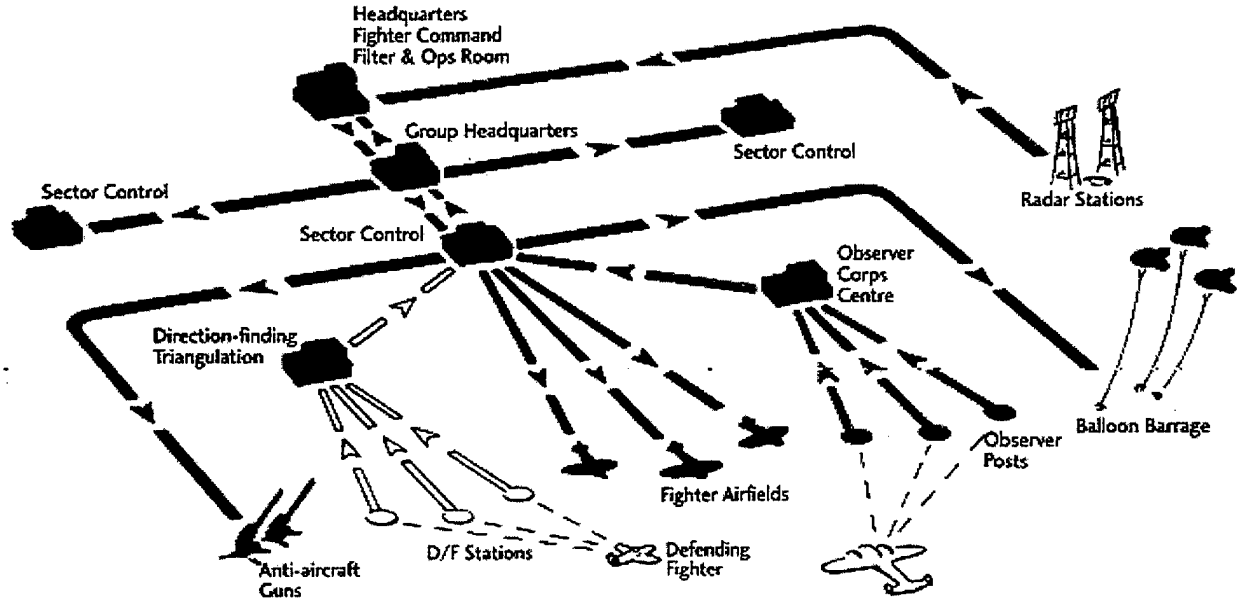

FIGURE 2, RAF FIGHTER CONTROL SYSTEM[25]

This integrated system brought all available weapons into play and allowed Britain to maximize the availability of a limited number of fighters. The system, which made the most of available radar information and situational awareness, was the only way that the slender number of fighters had a chance of being in the right place at the right time to oppose German fighters and attack the bombers.

Each Group was divided into several sectors with a number of airfields in each, and a Sector Control Station in charge of each sector. All the Sector Control Stations reported to their Group Headquarters and they in turn reported to Fighter Command Headquarters located deep underground at Bentley Priory. The Headquarters acted as a filter and communications center, collecting the reports from each radar station, resolving discrepancies and inaccuracies as well as they could. They plotted the course of each raid as well as the course of each RAF interceptor flight on a large map table.

From a balcony looking down on the map, Dowding and his officers decided which radar stations were to follow which raids and which squadrons were best able to intercept them. Status boards on the wall displayed the state of readiness of each available squadron. As the battle progressed, visual sightings from the Observer Corps at posts throughout the country were added to the map plots, and were passed by telephone to each group and sector that also tracked the battle.

Sector Controllers, who directly controlled the defenses, then knew exactly where the enemy was located and alerted the balloon sites in possible target areas to put up the balloon barrage. The purpose of these balloon barrages was to force German bombers higher, which

made aiming more difficult. Sector Controllers also warned the anti-aircraft guns along the probable route of the bombers to be ready when the enemy aircraft came within range.

Most importantly, the Sector Controller scrambled fighters from his sector airfields and vectored them to the incoming raid. With precious few fighters to defend Britain from attack, it was absolutely essential to maximize their efficiency and it was imperative to conserve aircraft and pilots as much as possible. Without this vital system, Fighter Command's aircraft would have wasted time and fuel constantly patrolling the coasts and some raids would have gotten through to their targets without interference.

As the Luftwaffe conducted its daily attacks, British radar spotted the intruders and fighters scrambled to the defense. Early warning did not guarantee success. Fighter Command pilots might intercept the attackers only to find themselves outgunned. Almost invariably, though, controllers knew the approximate numbers in an attacking formation and the RAF launched enough Spitfires and Hurricanes to shoot down more planes than they lost. Although few attacks could be thwarted completely, British fighters frequently made the attacking formations pay an inordinate price.

During the course of the July battles, the Germans were slow to grasp the importance of Britain's radar network and they never did understand how the system provided flexibility and reaction time to fighter command's control system. In fact a German intelligence report circulated on 7 August suggests that they had learned very little of the enemy they had been fighting for nearly a month, and points to their complete misunderstanding of the system:

> As the British fighters are controlled from the ground by R/T their forces are tied to their respective ground stations and are thereby restricted in mobility, even taking into consideration the probability that the ground stations are partly mobile. Consequently, the assembly of strong fighter forces at determined points and at short notice is not to be expected. A massed German attack on a target area can therefore count on the same conditions of light fighter opposition as in attacks on widely scattered targets. It can, indeed, be assumed that considerable confusion in the defensive networks will be unavoidable during mass attacks, and that the effectiveness of the defenses may therefore be reduced.[26]

AIRCRAFT

The RAF was born as a result of a devastating series of German bombing attacks. In the summer and autumn of 1917, German Gotha bombers launched a series of attacks of southwest England, and the Royal Flying Corps, serving under the British Army, was unable to do anything about them. Following public uproar over these attacks, Britain embraced the concept of airpower as an independent, revolutionary means of waging war. On April 1, 1918,

the RAF was established as an independent service under the command of General Sir Hugh Trenchard.[27]

In the decade following WWI, many military strategists around the world enthusiastically endorsed the bomber as the prime weapon of modern warfare. Italy's General Giulio Douhet said,

> A nation which has command of the air. . . can bomb the interior of an ememy's country so devastatingly that the physical and moral resistance of the people would also collapse. . . An aerial fleet capable of dumping hundreds of tons of bombs can easily be organized; therefore, the striking force and magnitude of an aerial offensive, considered form the standpoint of either material or moral significance, are far more effective that those of any other offensive yet known.[28]

Brigadier William 'Billy' Mitchell of the United States said of the tremendous potential of strategic bombing:

> Air power holds out the hope of the nations that in the future air battles taking place miles away from the frontiers will be so decisive and of such far-reaching effect that the nation losing them will be willing to capitulate without resorting to further contest on land or water. Aircraft operating in the heart of an enemy's country will accomplish their object in an incredibly short space of time once the control of the air has been established, and the months or even years of contest of ground armies with a loss of millions of lives will be eliminated in the future.[29]

In 1932, Stanley Baldwin, the former and future British Prime Minister, speaking in the House of Commons said:

> I think it is well for the man in the street to realize that there is no power on earth that can protect him from being bombed. Whatever people may tell him, the bomber will always get through. The only defense is offense, which means that you have to kill more women and children more quickly that the enemy if you want to save yourselves. I just mention that . . . so that people may realize what is waiting for them when the next war comes.[30]

It was this mindset - that there was no hope of creating an effective defense against bomber attack, that the only chance of protecting oneself was the strategic deterrence of one's own fleet of bombers - that dominated Britain's military vision between the two World Wars.

During this period, civilian designers were achieving technological advances, developing new materials, manufacturing methods, and new engines. However, because of the bomber focus, most British airmen were slow to grasp the significance of these revolutionary changes and new technology evolving in aircraft design and production. The British Bulldog, a biplane with an air-cooled radial engine capable of only 174 mph, remained Britain's first-line fighter until 1936.

Fortunately for Britain, two men who did not believe that the bomber would 'always get through' rose to leadership positions in the RAF just in time to prepare Britain for the coming battle. They understood that it was absolutely essential to defeat bomber attacks. In 1933, Sir Edward Ellington became the Chief of Air Staff, and Sir Hugh Dowding was appointed Commander-in-Chief of the newly created Fighter Command n 1936.[31]

They began to modernize Britain's fighter fleet, and toward the end of 1937, the first Fighter Command squadron was equipped with the new Hawker Hurricane. The Hurricane combined advanced features such as an enclosed cockpit and retractable landing gear with traditional manufacturing methods. Using a tubular metal structure and a fabric skin, the Hurricane could be easily and rapidly produced in existing facilities.

The Hurricane was a bridge between the biplanes of the past and the Spitfires of the 1940s. Although it was clearly outclassed by the Messerschmitt Bf109, it did achieve remarkable success in the Battle of Britain. Between July and October 1940, 1,715 Hurricanes took part in the Battle and claimed eighty percent of the German aircraft shot down by Fighter Command.[32] Although the Hurricane was a powerful, maneuverable aircraft capable of sustaining substantial combat damage, it was markedly inferior in terms of speed and rate of climb. Because of these limitations, they were generally used to attack the German bombers while the Spitfires fought with their fighter escorts.

The Supermarine Spitfire is one of the most famous aircraft of World War II. Designed by Reginald Mitchell, this completely new type of aircraft was revolutionary in several ways. Many of its features required new and complex manufacturing techniques. The fuselage was made in three sections: a tubular case for the Merlin engine, a monococque mid-section, and an aft section with the last two formers extending upwards to become the tail fin.

The wing spars were made up of girders that fit one inside the other. Each girder was a different length, so that the spar was the thickest at the root, where maximum strength was required, and hollow at the wingtip. The leading edge of the wing was covered with

heavy-gauge metal, making the wing very strong while the remainder of the wing was very thin. This technique made the wing very strong but light, minimizing drag while maximizing lift. The Spitfire was a match for the Bf 109 at every point except high altitude performance above 20,000 feet where the German fighter excelled.

BATTLE OF BRITAIN SUMMARY

The British had to repel Germany's air attack to prevent the Germans from launching an invasion attempt. If the Luftwaffe defeated Britain's fighters and gained air superiority, it would

be virtually impossible for Britain to successfully defend against attack. Britain's fate clearly rested on the shoulders of a few innovative thinkers who combined existing technology with new inventions to create a comprehensive defense.

By combining radar, an existing technology that others had been unable to effectively employ, with their ingenious Fighter Control System and a fleet of capable fighter aircraft, the British created a comprehensive defense which ultimately defeated Germany's onslaught. The application of technology and innovation clearly saved Britain from defeat by a militarily superior force.

The historical significance of successfully implementing strategic technology is as important today as it was during the Battle of Britain and it parallels the needs of a 21st century military. However, just as the British victory in the Battle of Britain actually started with inventions and innovations developed in the mid-1930s, the status of the United States' future as a world power may very well depend on technology development decisions made today.

DEFENSE OF THE UNITED STATES IN THE 21ST CENTURY

Many would use the British experience in the Battle of Britain as an example to prove the need for a National Missile Defense in the United States today. Just as British technology and innovation enabled them to defeat the German air onslaught, a National Missile Defense would conceivably enable the United States to defeat a missile attack. It has been over eighteen years since President Ronald Reagan outlined his Strategic Defense Initiative (SDI) as the only way to protect the United States against a ballistic missile attack. The threat then was the Soviet Union, and some even contend that Reagan's SDI convinced the Soviets that they could no longer compete against the United States. Yet despite the years of effort and millions of dollars spent on a National Missile Defense, the United States is still unprotected today.

President George W. Bush has vowed to make missile defense one of his top national security priorities. Today, the Cold War is over, but missile threats from China, Iran, and Russia are a concern and North Korea threatens U.S. bases in South Korea, Okinawa, and Guam.

Strategists claim that the main purpose of missile defenses is to prevent missiles from being used for blackmail and intimidation. Since nuclear weapons are so destructive and ballistic missiles are so hard to stop, any country with those weapons can blackmail and intimidate others. Credible missile defenses would greatly diminish the value of nuclear missiles.

However, there are a number of significant differences in Britain's strategic situation in 1940 and the geo-political setting of the United States today. Perhaps most obvious is the fact

that Germany was the clearly defined threat to the national interests of Great Britain and even posed a serious threat to her sovereignty. The British knew how the Germans would attack and generally, when the attack would occur. Conversely, the United States has no peer competitor today, nor is there a clearly defined threat to the nation's vital interests.

With the end of the Cold War, the United States has emerged as the world's only superpower. For a decade now, defense planning in the United States has attempted to determine how to transform its Cold War military forces into a 21st century force capable of meeting new and emerging threats across the entire spectrum of conflict. With no peer competitor, the United States has been without focus militarily, trying to be all things to all people.

With the absence of a clear opponent, leaders, planners and theorists have conducted numerous attempts to define this new force and its role. The 1997 National Military Strategy discusses the need for transformation:

> Preparing Now for an Uncertain Future. As we move into the next century, it is imperative that the United States maintains the military superiority essential to our global leadership. Our strategy calls for transformation of our doctrine and organizations and a stabilized investment program in robust modernization that exploits the Revolution in Military Affairs (RMA) and Business Affairs (RBA).[33]

The 1999 National Security Strategy offers a more detailed discussion of the concept of transformation:

> We must prepare for an uncertain future even as we address today's security problems. ... we must transform our capabilities and organizations – diplomatic, defense, intelligence, law enforcement, and economic – to act swiftly and to anticipate new opportunities and threats in today's continually evolving, highly complex international security environment. ... Within the military, transformation requires that we strike a balance among funding three critical priorities: maintaining the ability of our forces to shape and respond today, modernizing to protect the long-term readiness of the force, and transforming our unparalleled capabilities to ensure we can effectively shape and respond in the future. ... Transformation extends well beyond the acquisition of new military systems – we seek to leverage technological, doctrinal, operational and organizational innovations to give U.S. forces greater capabilities and flexibility.[34]

Joint Vision 2010 discussed the importance of technology and innovation. Joint Vision 2020 built on that theme, calling for organizational and conceptual innovation as well as technological innovation. In his 2000 Annual Report to the President and the Congress, Secretary of Defense William S. Cohen devoted an entire chapter to transformation of the military.

Unfortunately, despite years of talking about transformation and innovation, the United States today still has a Cold War military structured to fight two nearly simultaneous major theaters of war (MTW). The U.S. military is built to fight the last war, not the next one. The Bottom Up Review in 1993 and the Quadrennial Defense Review in 1997 did little to change the structure or focus of the United States military. Despite the talk of a Revolution in Military Affairs (RMA), of innovation and of new technology, the past decade has been characterized by gradual, incremental change intended to improve on the time-proven equipment and strategy that worked so well during the Cold War Period.

Back to the Battle of Britain: In the early 1930's, the British discovered they were poorly organized and equipped to defeat the imminent German invasion. Today, the United States, still organized and equipped to fight the Cold War, has come to the conclusion that it is ill-prepared for today's threats.

President Bush has set the stage for a sweeping review of the U.S. military strategy. He has vowed to set a long range vision for the military, stating that, "Today our military is still more organized for Cold War threats than for the challenges of a new century – for industrial age operations, rather than for information age battles."[35] During his presidential campaign, he pledged that upon becoming President, he would "begin an immediate, comprehensive review of our military – the structure of its forces, the state of its strategy, the priorities of procurement."[36]

To begin that analysis, Secretary of Defense Donald Rumsfeld tasked Andrew W. Marshall, director of the Pentagon's Office of Net Assessment (an internal think tank) to conduct an immediate review of how to structure U.S. forces. In conjunction with Marshall's quick look, Rumsfeld is conducting a longer, multi-part defense review. The scope of this top-to-bottom review encompasses financial management, acquisition reform, designing a national security strategy, military quality of life issues, and the organization of intelligence agencies.[37]

This review immediately follows the final report of the U.S. Commission on National Security/21st Century. This bipartisan commission of former national leaders co-chaired by former senators Gary Hart and Warren Rudman was chartered in 1998 to "analyze the emerging security environment (Phase I), develop a national strategy appropriate for that environment (Phase II), and recommend changes in organizations and processes to implement that strategy (Phase III)."[38] Their final report titled "Road Map for National Security: Imperative for Change," calling for sweeping changes was released 15 February 2001. Among other recommendations, the report called for the development of a new national security strategy, a

restructuring of federal agencies to defend against homeland threats, and abandoning the concept of the two MTW strategy.

Paul Wolfowitz, the newly confirmed Deputy Secretary of Defense confirms that a true RMA is imminent, stating, "I think everything's on the table including how you handle so-called two major regional contingencies and are they an abstraction or specifically North Korea and the Persian Gulf?"[39]

At the end of this sweeping introspective look, the Department of Defense will emerge with a new National Military Strategy to support the Bush Administration's National Security Strategy. It is obvious that the resulting military force will be based on capabilities, not on an ambiguous threat, and the resulting force will probably be significantly smaller than the current force. It may be significantly different as well. This healthy self-examination will demonstrate a serious need for innovative acquisition reform and revolutionary business practices. The current acquisition process simply takes too long to field new systems and current business systems are cumbersome and ineffective.

More important, however, are the pending technology and weapons systems decisions. If the U.S. military should no longer be trained and equipped for classic tank warfare in central Germany, what are the future threats and what kind of military is needed to deter or defeat them? What sort of revolutionary technologies would replace today's ships, tanks, and planes?

SHIPS

Revolutionary thinkers like Andy Marshall would reduce the number of aircraft carriers, claiming that carriers are lucrative targets for sea-skimming cruise missiles and would become increasingly vulnerable as those weapons get cheaper and more accurate. They claim that missions of the future will force ships to operate in coastal areas closer to shore. For these reasons, they do not believe the capabilities of the $5 billion ship with a crew of 5,000 sailors are worth the risks presented by future enemies. An analyst who worked on a recent net assessment study says, "The former icon of American power may become the baggage in the future. Instead of saying, 'Send in the carrier,' the President may say, 'Get it the hell out of there before they get hit with a missile salvo.'"[40] Carrier critics promote such alternatives as the 'arsenal ship' which is essentially a missile barge built of stealth materials. It would present a low profile to make it hard to find and a two-layer hull for protection. It would carry a crew of 20 or less, and its 500 missiles could be launched and controlled from other platforms.

Others promote the DD-21, a new class of multi-mission destroyer with a land attack focus. Although this ship would be capable of engaging threats at sea, in the air, and ashore, it

is designed primarily for the purpose of providing fire support to ground forces ashore. This revolutionary ship, manned by a crew of only 95 would incorporate stealth technology and a new advanced gun system.

TANKS

Upon being appointed to the position of Army Chief of Staff, General Eric Shinseki launched a revolutionary effort to transform the Army. Realizing that 70-ton M-1 tanks and their huge logistics tail threatened to make the Army an irrelevant force in the 21st Century, Shinseki declared, "Heavy forces must be more strategically deployable and more agile, with a smaller logistical footprint, and light forces must be more lethal, survivable and tactically mobile."[41] To meet this goal, the Army has invested most of its research and development money into the development of the Future Combat System, which would ultimately replace all existing tanks and infantry fighting vehicles.

The envisioned vehicle would be a 20 ton wheeled vehicle that can be transported by C-130 transports. The Army challenged the industrial base to produce a system with revolutionary protection, drive, and weapons systems.

In the interim, the Army has equipped two brigades with the Light Armored Vehicle III (LAVIII) to serve as an Interim Armored Vehicle (IAV) until the new systems are developed and tested. Current plans call for five brigades to be equipped with the IAV.

AIRCRAFT

Perhaps the most expensive of all the pending technology and weapons systems decisions facing the Department of Defense concern aircraft. Is the F-22 affordable? Is it wise to spend so much on a single aircraft? Is the V-22 safe/reliable? How much transport capacity is enough for tomorrow? These are questions of immediate concern, but there are broader, more far-reaching technological developments as well. Unmanned aerial vehicles (UAV) are rapidly changing the very nature of military aviation.

The Global Hawk, an Advanced Concept Technology Demonstration program, is an unmanned platform designed as a possible replacement for the U-2. The air vehicle, which first flew from Edwards Air Force Base, CA on 28 February 1998, will be capable of standoff, sustained high altitude surveillance and reconnaissance. It will operate at ranges up to 3000 nautical miles from its launch area, with loiter capability over the target area of up to 24 hours at altitudes greater than 60,000 feet. It will be capable of simultaneously carrying electro-optical (EO), infrared (IR), and synthetic aperture radar (SAR) payloads, and will be capable of both wideband satellite and Line-Of-Sight (LOS) data link communications.[42]

Northrop Grumman is building a naval unmanned combat aerial vehicle (UCAV) together with the U.S. Navy and the Defense Advanced Research Project Agency (DARPA). The kite-shaped Pegasus, which is designed to be carrier-based, will operate above 35,000 feet at a range of some 900 miles with at least a 2,000 pound payload. The 5,500 pound aircraft is being built of composite materials and will have a wingspan of just over 27 feet. In a joint statement, the Navy and DARPA said, "By removing the pilot from the vehicle a new standard in aircraft affordability and supportability will be achieved. Capitalizing on technical advances by UCAVs will provide the nation with increased tactical deterrence at a fraction of the costs of current manned systems."[43]

On 21 February 2001, the U.S. Air Force's Air Combat Command and Aeronautical Systems Center successfully launched a live Hellfire missile from a Predator UAV. In the live-fire test, the Predator was commanded via a Ku-band satellite link, out of line of sight of the controllers. The Predator flew to 2,000 feet, lased its own target, and fired the Hellfire, scoring a direct hit on the target.

The U.S. Army has conducted a series of four experiments to investigate the capabilities derived from combining manned and unmanned (MUM) aerial platforms. The most recent test was conducted to determine if a UAV controlled from the cockpit of an AH-64D Longbow attack helicopter could provide enhanced situational awareness to the helicopter crew and maneuver commanders. In this very successful experiment conducted at the Joint Readiness Training Center, the AH-64D received telemetry data from the UAV at a distance of 58 kilometers and video transmission from 30 kilometers.[44] This integration will aid future commanders and aircrews in target identification, threat avoidance, and will allow the development of effective fire distribution plans prior to engaging the enemy.

INFORMATION WARFARE

A growing element in the U.S. defense sector is learning to fight with information as a weapon. Information warfare involves a number of technologies including computer network attacks and defense. COL David Stinson, vice commander of the Air Force Information Warfare Center claims that information warfare can be used as a flexible deterrent option prior to prevent conflict from erupting. He explains,

> If you want a show of force to prove you can deny something of value, I can reach out and pick out some capability that hurts with no collateral damage and no loss of life. That makes information warfare a big and valuable player in that period (before combat begins). The goal is for things that deter a conflict or shape conditions that might produce an agreement. Information operations create that kind of leverage.[45]

While researchers are currently working to make information warfare more operationally relevant, others point out that the U.S. conducted information operations against Iraq during Desert Shield/Desert Storm and again during the 1998 Kosovo air campaign. According to a senior pentagon official, the first attack was limited to reading the e-mail of Iraqi commanders. In the Kosovo bombing campaign, false messages and targets were injected into Yugoslavia's complex computer-integrated air defense system.[46]

With the obvious potential of offensive information warfare, the U.S. has devoted a significant defensive effort to protect its systems from attack. Both the number and the sophistication of attempted intrusions to government computer networks are increasing rapidly. Although most attacks are thought to be the attempts of hackers, evidence indicates that nations, most notably China, are aggressively probing U.S. computer systems.

SPACE

Very simply, for the U.S. to remain a global superpower, the nation must maintain its present control of space. According to the Commission to Assess Unites States National Security Space Management and Organization, commonly called the Space Commission, the U.S. must do a better job of using space to harness the military needs of the Nation. The commission concluded,

> Our growing dependence on space, our vulnerabilities in space and the burgeoning opportunities from space are simply not reflected in the present institutional arrangements. . . . Having shown the world the utility of space systems, it would be pretty naïve to think that our adversaries are just going to be sitting around idly and not developing their own space-based information capabilities and the tools and techniques to counter the current U.S. space advantage.[47]

The report, which was released in January, concludes that just as air, land, and sea were the theaters of battle in the 20th Century, space will be the battlefield in the 21st Century.

CONCLUSION

With Operation SEA LION, Germany posed a very real threat to British sovereignty. If Germany's air campaign succeeded in eliminating RAF's Fighter Command, Britain would be unable to repel the invasion which would follow. However, Britain overcame the threat of a German invasion by brilliantly analyzing the threat and developing technological solutions starting in the mid-1930s. They developed an innovative system to detect intrusion then combined it with an ingenious control system to guide their modern fighters to intercept German

air raids. Technology, innovation, and national will protected Britain's sovereignty and led to the failure of Germany's invasion in the summer and fall of 1940.

Some would use the Battle of Britain as an example to encourage the construction of a National Missile Defense. Technology and innovation succeeded in stopping the German invasion. Despite the conventional military thinking of the day, technology and innovation provided a way to defeat the bombers that would 'always get through.' Similarly, technology and innovation could provide a way to defeat missiles, the modern 'bomber that will always get through.'

The United States faces an entirely different and potentially more difficult situation in the 21st Century than the British faced in 1940. While Britain had a clearly identified threat and even knew basically when and how Germany would attack, the United States is faced with a much more ambiguous situation. There is no peer competitor; the U.S. is the world's sole superpower. As such, the U.S. must constantly retain the ability to militarily protect its interests throughout the entire spectrum of conflict – from peacetime engagement to peacekeeping to small scale and regional conflicts to all-out war.

Today, the United States is conducting a sweeping review of U.S. military strategy, force structure, and weapons. President Bush has vowed to set a long-range vision for the military and to review procurement priorities. The resulting military force will be based on capabilities, not on an ambiguous threat, and the resulting force will probably be significantly smaller than the current force. It may be significantly different as well. Revolutionary new weapons systems and capabilities are being developed and President Bush has indicated a propensity to embrace new technology instead of improving current Cold War systems.

The United States must be prepared to act immediately throughout the world across the entire spectrum of conflict. Despite the ambiguity, despite the uncertainty, the United States must prepare for the future with the clarity and unity of purpose that Britain prepared to defend herself from Germany. Focused innovation and technology will enable the United States to win the battles of the future just as they enabled Britain to prevail in 1940.

WORD COUNT = 9089

ENDNOTES

[1] Len Deighton, Battle of Britain (London: George Rainbird Limited, 1980), 13.

[2] John Colville, The Fringes of Power: 10 Downing Street Diaries 1939-1955, (London: Norton, 1985) quoted in Charles Fox, "The Last of the Few," Air and Space, June/July 1990, 50.

[3] Dr. Neil Young, "Foundations of Victory: The Development of Britain's Air Defenses 1934-1940," RUSI Journal, Autumn 1990, 67.

[4] Deighton, 71.

[5] Heinz Magenheimer, Hitler's War: German Military Strategy 1940-1945, trans. Helmut Bogler (London: The Cassell Group, 1998), 21.

[6] Royal Air Force Fighter Command. "Battle of Britain – 1940." available from <http://battleofbritain.net/section-5/page22.html>; Internet; accessed 18 December 2000.

[7] British Air Ministry, The Rise and Fall of the German Air Force 1933-1945, (Bath: Pittman Press, 1948) reprinted (London: Crown, 1983), 75.

[8] Royal Air Force Fighter Command, 5.

[9] Ibid., 5.

[10] Ibid., 6.

[11] British Air Ministry, 79.

[12] Royal Air Force Fighter Command. "Battle of Britain – 1940." Available from <http://battleofbritain.net/section –5page23.html>; Internet; accessed 18 December 2000.

[13] Ibid., 12.

[14] C.V. Glines, "Their Finest Hour," Air Force Magazine, September 1990, 110.

[15] Ibid., 111.

[16] Magenheimer, 35-36.

[17] Glines, 111.

[18] Ibid., 112.

[19] Deighton, 151.

[20] Glines, 112.

[21] The Royal Air Force, "The Battle of Britain," Available from <http://www.raf.mod.uk/bob1940/phase4.html>; Internet; accessed 20 February 2001.

[22] DERA, "Early Radar Development," Available from <http://www.dera.gov.uk/html/whoweare/history/early_radar_development.htm>; Internet; accessed 25 January 2001.

[23] Ibid., 3.

[24] Royal Air Force Fighter Command, 3.

[25] The Royal Air Force, "The Battle of Britain," Available from <http://www.raf.mod.uk/bob1940/controlsys.html>; Internet; accessed 25 January 2001.

[26] British Air Ministry, 80.

[27] Deighton, 9.

[28] Ibid., 12.

[29] Ibid., 13.

[30] Ibid., 13.

[31] Ibid., 33.

[32] The Royal Air Force, "The Battle of Britain," Available from <http://www.raf.mod.uk/bob1940/hurricane.html>; Internet; accessed 25 January 2001.

[33] John M. Shalikashvili, National Military Strategy of the United States of America; Shape, Respond, Prepare Now: A Military Strategy for a New Era, 1997 (Washington, D.C: The Joint Staff, 1997), 3.

[34] William J. Clinton, A National Security Strategy for a New Century (Washington, D.C.: 1999), 20-21.

[35] Thomas E. Ricks, "Pentagon Study May Bring Big Shake-Up," Washington Post, 9 February 2001, p. 1.

[36] Ibid.

[37] Linda de France, "Rumsfeld Offers Insight Into Defense Reviews, Budget Shortfalls," Aerospace Daily, 2 March 2001.

[38] Dennis Steele, "National Security Commission Recommends a New Strategic Outlook," Army: The Magazine of the Association of the United States Army, March 2001, p. 37.

[39] De France, 2.

[40] Richard J. Newman, "Tough Choices," U.S. News and World Report, 26 February 2001.

[41] Daniel Goure, "Army Leads Transformation," Defense News, 26 February 2001, p. 32.

[42] Federation of American Scientists, "RQ-1A Global Hawk (Tier II + HAE UAV)." available from <http//www.fas.org/ipr/program/collect/global_hawk.htm>; Internet; accessed 2 March 2001.

[43] Jim Skeen, "Unmanned Craft Building Begins," Los Angeles Daily News, 26 February 2001, sec. A, p. 1.

[44] MG Anthony R. Jones, "UAV-Air Maneuver Integrated Operations," Army Aviation, 28 February 2001, 10.

[45] David A. Fulghum and Robert Wall, "Cyber-Arsenal Needs Testing," Aviation Week and Space Technology, 26 February 2001, 57.

[46] David A. Fulghum and Robert Wall, "Combat-Proven Infowar Remains Underfunded," Aviation Week and Space Technology, 26 February 2001, 52.

[47] Robert Holzer, "IT, Space Top U.S. Military Priorities," Defense News. 26 February 2001, 22.

BIBLIOGRAPHY

Associated Press. "All Handhelds on Deck." Boston Globe, 22 February 2001, p. 6.

Bond, David. "Uncertainties, Doubts Cloud Information Warfare Policy." Aviation Week and Space Technology, 26 February 2001, p. 61.

Brinkley, C. Mark. "The People Zapper." Marine Corps Times, 5 March 2001.

British Air Ministry, The Rise and Fall of the German Air Force 1933-1945. Bath: Pittman Press, 1948. Reprinted in London: Crown, 1983.

"British Technical Innovations of World War II: Radar." Available from <http://british-forces.com/world_war2/Technical/radar.html>. Internet. Accessed 25 January 2001.

Buderi, Robert. The Invention That Changed the World. New York: Simon & Shuster, Inc. , 1997.

Burger, Kim. "Thornberry Outlines Possibilities For Military That Accepts Change." Inside the Army. 19 February 2001, p. 11.

Clinton, William J. A National Security Strategy for a New Century. Washington, D.C.: The White House, 1999.

Cohen, William C. Annual Report to the President and the Congress. Washington, D.C.:U.S. Department of Defense, 2000.

"Consequences Of A New U.S. Defense Strategy." Stratform.com, 1 March 2001.

Dao, James. "Pentagon Unveils Plan For A New Crowd-Dispersal Weapon." New York Times, 2 March 2001.

de France, Linda. "Northrop Grumman Prepares to Fly Naval UCAV Demonstrator." Aeorspace Daily, 27 February 2001.

de France, Linda. "Predator Fires Live Missile In First Test of Weaponized UAV." Aerospace Daily, 23 February 2001.

de France, Linda. "Rumsfeld Offers Insight Into Defense Reviews, Budget Shortfalls." Aerospace Daily, 2 March 2001.

Deighton, Len. Battle of Britain. London: George Rainbird Limited, 1980.

Deighton, Len. Fighter. New York: Alfred A. Knopf, Inc., 1977.

DERA. "Early Radar Development." Available from <http://www.dera.gov.uk/html>. Internet. Accessed 25 January 2001.

Downing, Taylor and Andrew Johnston. "The Spitfire Legend." History Today, (September 2000): 19-25.

Eisman, Dale. "Longtime Pentagon Adviser Promotes A Less Visible Military." Norfolk Virginian-Pilot, 23 February 2001.

Federation of American Scientists. "RQ-1A Global Hawk (Tier II + HAE UAV)." Available from <http://www.fas.org/ipr/program/collect/global_hawk.htm>. Internet. Accessed 2 March 2001.

Fox, Charles. "The Last of the Few." Air & Space, (June/July 1990): 50-61.

Fulghum, David A. and Robert Wall. "Combat-Proven Infowar Remains Underfunded." Aviation Week and Space Technology, 26 February 2001, p. 52.

Fulghum, David A. and Robert Wall. "Cyber Arsenal Needs Testing." Aviation Week and Space Technology, 26 February 2001, p. 57.

Fulghum, David A. and Robert Wall. "U.S. Shifts Cyberwar to Combat Commands." Aviation Week and Space Technology, 26 February 2001, p. 50

Gerry, Alexander. "Quadrennial Defense Review 2001: A Study by the National Defense University." ROA National Security Report: A Publication of the ROA Defense Education Forum. Washington, D.C.: Reserve Officers Association of the United States, January/February 2001.

Glines, C.V. "Their Finest Hour," Air Force Magazine, (September 1990): 110-112.

Goure, Daniel. "Army Leads Transformation." Defense News, 26 February 2001, p. 32.

Greenway, H.D.S. "A Better Idea for Employing US Marines." Boston Globe, 26 February 2001, p. 15.

Hebert, Adam J. "Gansler Says Air Force Faces Difficult Modernization Decisions." Inside The Air Force, 23 February 2001, p. 11.

Heilenday, Frank W. The Battle of Britain – Luftwaffe Vs. RAF: Lessons Learned and Lingering Myths From World War II. Santa Monica, CA: Rand, 1995.

Holzer, Robert. "IT, Space Top U.S. Military Top Priorities." Defense News, 26 February 2001, p. 22.

Holzer, Robert. "Top U.S. Military Strategist Faults Navy Innovation." Defense News, 12 February 2001, p. 1.

Horne, Jeffery C. Information Superiority As An American Center of Gravity: Concepts for Change in the 21st Century. Strategy Research Project. Carlisle Barracks: U.S. Army War College, 10 April 2000.

Jones, Anthony R. "UAV-Air Maneuver Integrated Operations," Army Aviation. 28 February 2001.

Kitfield, James. "A Small Study Carries A Heavy Burden." National Journal, 3 March 2001.

Krauthammer, Charles. "The Bush Doctrine." Time. 5 March 2001, 42.

Lowe, Christian. "Defense Officials Urge Innovation In Acquisition." Defense Week, 20 February 2001, p. 1.

Lowe, Christian. "Global Hawk Drone Moves Into Full-Scale Development." Defense Week, 26 February 2001, p. 3.

Magenheimer, Heinz. Hitler's War: German Military Strategy 1940-1945, Translated by Helmut Bogler. London: The Cassell Group, 1998.

Monsarrat, John. "Radar in Retrospect." Journal of Electronic Defense, October 1991, 92-113.

Mulholland, David. "US Armed Forces, Industry Push Procurement Reform." Jane's Defense Weekly, 28 February 2001.

Murray, Williamson. "The Battle of Britain: How Did 'the Few' Win," in Experience of War. New York: Dell Publishing, 1992.

Newman, Richard J. "Tough Choices." U.S. News and World Report, 26 February 2001.

Radar: A Report on Science at War. Washington, D.C.: U.S. Government Printing Office, 1945.

Ray, John. The Battle of Britain: New Perspectives. London: Arms and Armour Press, 1994.

"Redefining Defense." Boston Globe, 20 February 2001, p. 14.

Ricks, Thomas E. "Pentagon Study May Bring Big Shake-Up." Washington Post, 9 February 2001, p. 1.

Royal Air Force Fighter Command. "Battle of Britain – 1940." Available from <http://battleofbritain.net.html>. Internet. Accessed 18 December 2000.

Rudman, Warren B. and Josh S. Weston. "Improving The Business End Of The Military." Washington Post, 21 February 2001, p. 23.

Scott, William B. "Network Security Still The 'Wild West.' Aviation Week and Space Technology, 26 February 2001, p. 62.

Shalikashvili, John M. Joint Vision 2010. Washington, D.C.:US Government Printing Office.

Shalikashvili, John M. National Military Strategy of the United States of America: Shape, Respond, Prepare Now: A Military Strategy for a New Era, 1997. Washington, D.C: The Joint Staff, 1997.

Shelton, Henry H. Joint Vision 2020. Washington, D.C.: US Government Printing Office, June 2000.

Sinnreich, Richard Hart. "In Defense Planning, Assumptions Determine Conclusions." Lawton (OK) Constitution, 18 February 2001, p. 4.

Skeen, Jim. "Unmanned Craft Building Begins." Los Angeles Daily News, 26 February 2001, p. AV1.

Steele, Dennis. "National Security Commission Recommends a New Strategic Outlook." Army. March 2001. p. 37.

The Royal Air Force, "The Battle of Britain." Available from <http://www.raf.mod.uk/bob1940.html>. Internet. Accessed 20 February 2001.

Tiboni, Frank. "U.S. Army Special Forces Battle Acquisition Barriers." Defense News, 26 February 2001, p. 6.

Wall, Robert and David A. Fulghum. "New Tools Emerge For Info War Battle." Aviation Week and Space Technology, 26 February 2001, p. 58.

Wall, Robert and David A. Fulghum. "Putting the Spin On Modern War." Aviation Week and Space Technology, 26 February 2001, p. 64.

Waller, J. Michael. "Militarizing Space." Insight, 19 March 2001.

Warden, John A. III. "The New American Security Force." Airpower Journal 13, no.3 (Fall 1999): 75-91.

Wolfe, Frank. "Commission Recommends Additional Base Closures, Biennial Budgeting." Defense Daily, 23 February 2001, p. 1.

Wolfe, Frank. "White House Requests $310.5 Billion In FY'02 for Pentagon." Defense Daily, 1 March 2001, p. 1.

Young, Neil. "Foundations of Victory: The Development of Britain's Air Defenses 1934-1940," RUSI Journal, (Autumn 1990): 62-67.

Zuckerman, Mortimer B. "Rethinking the Next War." U.S. News and World Report, 5 March 2001.